



Constancy and Kinetics of Direct Yellow 27 from Aqueous Solution using *Balsamodendron caudatum* Wood Squander Activated Nano Springy Carbon Material

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Abstract

The sorption competence of *Balsamodendron caudatum* wood waste comparative to Direct Yellow 27 was analyzed to check its significance in textile waste water association. *Balsamodendron caudatum* wood squander activated nano springy carbon material (BANCM) was treated by means of sulphuric acid to make a choice up sorption ability for the exclusion of Direct Yellow 27 (C.I. No 13950) from aqueous solution. The treated (BANCM) using sulphuric acid was determined through SEM, XRD and FT-IR. Contemporary learning deals with the use of BANCM squander as adsorbent for the removal of Direct Yellow 27 dye from its aqueous solutions. The investigation point out that sorption is perfunctory by initial dye concentration, dye solution pH and sorption temperature have been investigated in the present study. Kinetic force of dye followed the pseudo-first-order, pseudo second-order and Elovich models respectively. Consequences show that the pseudo first order kinetic model was established to compare the investigational description excellent.

Keywords Aqueous solution; Direct Yellow 27; Kinetics; Low-priced adsorbents; Sorption.

1. INTRODUCTION

Nowadays, the textile industry plays a key role in the economy of countries around the world (Amin, 2009). Among the textile operation, dyeing is a fundamental process which produces large volume of colored wastewater that can affect environmental ecosystems, especially aqueous ambient. Direct Yellow 27 is an azo dye group with three azo bonds. The potential toxicity and carcinogenicity of azo dyes has been reported (El-Bahy *et al.* 2009). In addition to aesthetically displeasing, some dyes (as azo group dye) are toxic to some microorganisms and may cause direct destruction or inhibition of their catalytic activities (Armagan *et al.* 2004). According to reports, Direct dyes constitute about 17% of all dyes employed for dyeing textiles and about 30% of dyes used for dyeing cellulose fiber (Sax, 1981). Therefore, this products need to be treated before delivery. The conventional methods for the decolorization of dyes from aqueous solutions are oxidation, precipitation, ion exchange, bio-sorption, electrochemical treatment, and adsorption (Bulut *et al.* 2007; Shirmardi *et al.* 2013). Such types of adsorbents include pine tree leaves (Deniz *et al.*

2011)., bagasse fly ash(Mane *et al.* 2007). rice husk ash (Mane *et al.* 2007), (Arundo donax) reeds (Arwa Abdelhay *et al.* 2017), red mud (Zhong-Pan Hu *et al.* 2017) TiO₂ (Dayeon ChoiSooHo HamDu-Jeon Jang, *et al.* 2018) nanocomposites agricultural waste and timber industry waste carbons for the removal of various dyes from wastewaters (Bansa, *et al.* 2009). Critical review of low cost adsorbents for wastewater treatment has been presented by earlier researchers (Demirbas, *et al.* 2009).

2. EXPERIMENTAL METHODS

2.1 Adsorbent

Balsamodendron caudatum wood waste was obtained from various places of Coimbatore & Tirupur Districts, Tamil Nadu, and India. The study of *Balsamodendron caudatum* wood waste material is used as sorbent is expected to be low-cost, environmentally safe and it has practical significance. To develop sorbents, the material was first ground and washed with distilled water and then dried. The dried material thus obtained was treated with hydrogen

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peroxide (40% W/V) at room temperature for about 24 hrs to oxidize the adhering organic matter. The resulting material was thoroughly washed with doubly distilled water and then subjected to the temperature of 120°C for the moisture removal. One portion of the above material was soaked well with H₂ SO₄ solution for a period of 24 hours. At the end of 24 hrs the excess of H₂ SO₄ solution were decanted off and air-dried. Then the materials were placed in the muffle furnace carbonized at 120-130°C. The dried materials were powdered and activated in a muffle furnace kept at 800°C for a period of 60 minutes. After activation, the obtained carbon was washed sufficiently with large volume of water to remove free acid. Then obtained material was washed with plenty of water to remove excess of acid, dried then to desired particle size. The resulting carbon named as BANCM.

2.2 Preparation of aqueous dye solution

The stockpile solutions of the dye (1000 ppm) were prepared by dissolving 1 g of dye in one litre of water without any more treatment, which were kept in dark colored glass bottles. For batch study, an aqueous solution of this dye was prepared from stock solutions in deionized water. NaOH and HCl solutions were used as buffers for pH studies.

Table 1. Individuality of the dye used

Class	Sample	General name	C.I. No.	Mw
Direct	DI 27	Direct Yellow 27	13950	662.63

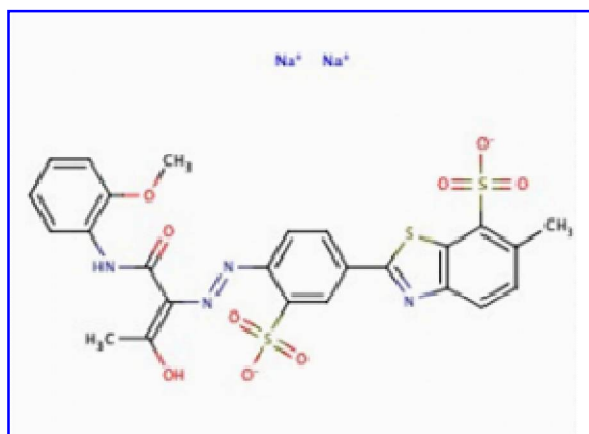


Fig. 1: Structure of Direct Yellow 27

The pseudo first – order equation

The pseudo first - order equation (Lagergren *et al.* 1898) is generally expressed as follows:

$$\frac{dq_t}{dt} = k_1(q_e - q_t) \quad (1)$$

where, q_e and q_t are the adsorption capacity at equilibrium and at time t , respectively (mg g^{-1}), k_1 is the rate constant of pseudo first –order adsorption (l min^{-1}).

The Pseudo Second – Order Equation

The pseudo second – order adsorption kinetic rate equation is expressed as (Mckay *et al.* 2000)

$$\frac{dq_t}{dt} = k_2(q_e - q_t)^2 \quad (2)$$

where, k_2 is the rate constant of pseudo second order adsorption ($\text{g. mg}^{-1} \cdot \text{min}^{-1}$). where, k_2 is the rate constant of pseudo second order adsorption ($\text{g. mg}^{-1} \cdot \text{min}^{-1}$). If the initial adsorption rate h ($\text{mg g}^{-1} \text{min}^{-1}$) is

$$h = k_2 q_e^2 \quad (3)$$

The Elovich Equation

The Elovich model equation is normally expressed (Chien *et al.* 1980) as

$$\frac{dq_t}{d_t} = \alpha \exp(-\beta q_t) \quad (4)$$

where, α is the initial adsorption rate ($\text{mg.g}^{-1} \text{min}^{-1}$), β is the adsorption constant (g. mg^{-1}) during any one experiment.

3. RESULTS & DISCUSSION

3.1 Characterization of adsorbent

The surface area of the BANCM was calculated through N₂ adsorption at 77K using a NOVA1000, Quanta chrome company. The pH of BANCM was measured by a PHS-3C pH meter. pH of zero charge (pHpzc) of the samples was resolute using pH drift method (Fariaa *et al.* 2004) The surface area of the BANCM obtained from the N₂ equilibrium adsorption isotherms was found to be 760 m²/g. The results of “pH drift” test, from which the pHpzc of BANCM studied in this test was found to be 4. The better colour removal of the dye, Direct Yellow 2 was observed at pH of 6.

3.2 Effect of pH

From the set of experiments conducted to find the effect of pH on sorption phenomenon, it was observed that pH influences BANCM surface dye binding sites and the dye chemistry in water. Fig. 2 show the quantity of dye removed, using acid activated sorbent at initial pH value. In this experiment, the initial dye concentration was fixed at 20 ppm. From the shake flask experiments, better colour removal of the dye, Direct Yellow 27 was observed at pH of 6. The uptake of Direct Yellow 27 was establish to be optimal at pH 6 with the utmost dye uptake of 89 %. As the surface charge density decreases with an increase in the solution pH, the electrostatic repulsion between the positively charged dye and the surfaces of sorbent is reduced, this causes more sorption (Krupadam *et al.* 2003). At pH above pH_{zpc} , the surface of adsorbent may acquire a negative charge leading to an increased cationic dye adsorption, due to electrostatic attraction.

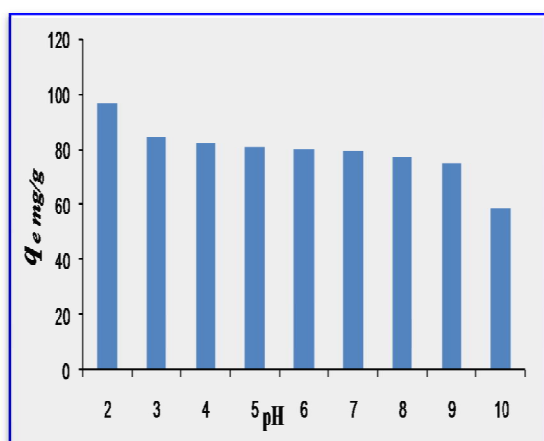


Fig. 2: Effect of pH on % of removal of Direct Yellow 27 by BANCM

3.3 Effect of concentration

The batch adsorption experiments were carried out by using three different concentrations of dye viz. 20mg/L, 40mg/L and 60mg/L at pH 6. at the reaction temperature of 30 °C were selected for adsorbent. The rate of agitation was maintained constant at 200 rpm. The colour fall profiles were obtained using the absorbent BANCM measurements.

3.4 SEM analysis

The morphological study by SEM of the adsorbent shown in the Fig. 3 exposed that, it is extremely porous in nature. From the SEM results, it was found that there are identical holes and cave type openings on the surface of the sample that would

absolutely have greater than before the surface area (Khattri *et al.* 2000).

3.5 XRD analysis

Fig. 4 shows the wide angle XRD pattern for nano porous carbon sample. The XRD analysis of nano porous carbon proved that the carbon prepared by acid treatment shows the X-ray diffraction angle $2\theta = 23$ it is similar to the reported graphitization wood waste (Syed, 2003).

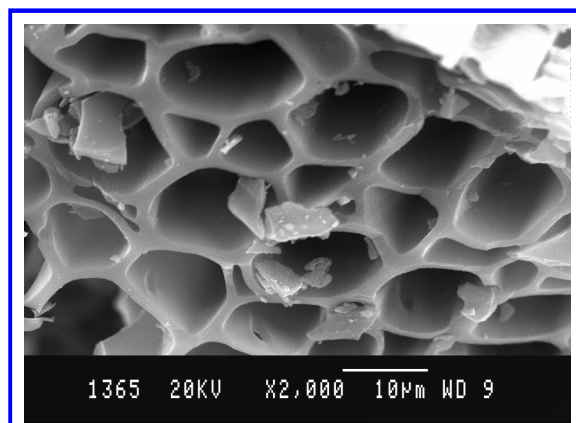


Fig. 3: SEM analysis for BANCM

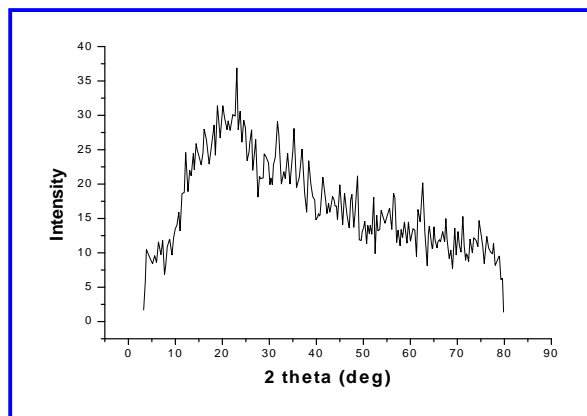


Fig. 4: XRD pattern for BANCM

3.6 FT-IR analysis

The FT-IR spectrum of the *Balsamodendron caudatum* wood waste activated nano porous carbon prepared by a range of treatment processes shown in the Fig. 6 revealed that the carbon sevaluated contain four classes of surface groups: carboxyls, lactones, phenols and carbonyls. The task of the exact wave number to a given functional group was not possible because the sorption bands of different functional groups overlap and shift depending on their molecular

structure and environment. Shifts in absorption position may be caused by factors such as intramolecular and intermolecular hydrogen bonding, steric effect and degree of conjugation (Kendall *et al.* 2000).

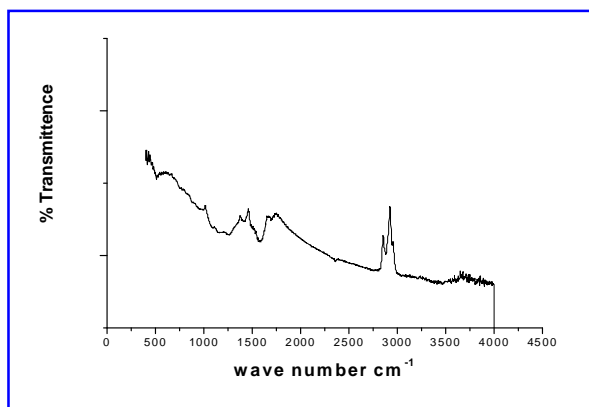


Fig. 5: FTIR Spectra for BANCM

3.7 TGA-DTA Analysis

The Thermal stability of the carbon materials prepared by sulphuric acid was analyzed by the TG&DTA are shown in Fig. 6. The curve clearly illustrate that the carbon samples begin to lose weight at about 60° C due to the volatilization of small molecules and it started to lose weight intensively above 600° C may be due to the decomposition of polymeric (or) aromatic molecules formed during the carbonization process.

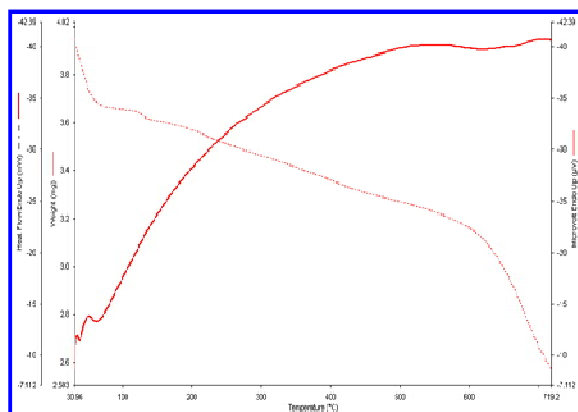


Fig. 6: TGA Curve for BANCM

3.8 Effect of Temperature on Kinetic Rate Constant and Rate Parameters

Sorption experiment was conducted out with fixed initial dye concentration (20mg/L) at pH 6 and at various temperature viz. 30 °C, 45 °C and 60 °C. The investigation of the data in (Table 2) reveals that the influence of temperature of the dye has very little influence on the pseudo second order rate constants. The table 2 also reveals that the influence of the temperature of dye on Elovich and pseudo first order rate constant is neither considerable nor small. It is obvious that the sorption of dye on the BANCM waste activated carbon is best described by first order rate equation with regression coefficient value is larger than 0.98.

Table- 2: The sorption kinetic model rate constants for BANCM various temperature

Adsorbent	Initial Temp.	Pseudo first order		Pseudo Second order			Elorich Model		
		k_1 l min^{-1}	r^2	k_2 $\text{g mg}^{-1} \text{min}^{-1}$	h $\text{mg g}^{-1} \text{min}^{-1}$	r^2	β g min^{-1}	α $\text{mg g}^{-1} \text{min}^{-1}$	r^2
BANCM	30°C	0.0527	0.9967	0.00887	0.6287	0.8238	0.1678	0.4548	0.9899
	45°C	0.0099	0.8855	0.0688	6.4489	0.6567	0.1928	0.82466	0.9389
	60°C	0.09014	0.7787	0.0646	0.2158	0.4369	0.4956	0.6357	0.9798

4. CONCLUSION

Adsorption of Direct Yellow 27 dye on the BANCM was ascertain to be dependent on the pH, (The optimal pH of Direct Yellow 27 was 6), temperature and concentration for sorbent. Sorption equilibriums were reached within 220 min contact time for Direct Yellow 27 dye used in this test. The percentage saturation was found to be almost 99% for the BANCM respectively. The kinetics of Direct Yellow 27 adsorption on adsorbent was found to follow a pseudo first-order rate equation. The adsorbent was employed to adsorb Direct Yellow 27 from aqueous solution openly and showed high removal competence at suitable conditions, indicating that the secondary adsorption was an efficient and inexpensive way for reuse of the used sorbents. An equilibrium isotherm for the sorption of Direct Yellow 27 on BANCM was analyzed by the Freundlich, and Langmuir isotherm equations. Final result showed that the Freundlich isotherm best-fit the Direct Yellow 27 adsorption.

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